355 Lasers and Nonlinear Optics

Syllabus Spring 2004

Ivan Biaggio
415 Lewis Lab
(610) 758-4916
biaggio@lehigh.edu
http://www.lehigh.edu/~ivb2/

Class Schedule:

MWF between 9:10 am and 10:00 am.

Course description:

This course is designed for advanced undergraduate and graduate students having some previous exposure to the field of optics, and wishing to become knowledgeable in the basic principles that govern the operation of lasers and the light-matter interaction effects collectively known as nonlinear optics.

For *lasers*, we will discuss the following: basic principles that allow laser operations, namely stimulated emission, population inversion, and resonators. Temporal and spatial coherence of laser light. Gaussian beams. Laser resonators. Q-switching, mode-locking, cavity dumping. Review of the most common laser systems used in science and technology.

In *nonlinear optics*, the basic treatment will include the origin, symmetry, and definitions of the nonlinear optical susceptibilities. Experiments and applications will be selected from among the following topics: Measurement of nonlinear optical properties and the pitfalls of inconsistent definitions found in the literature; Molecular hyperpolarizabilities and macroscopic nonlinearities; Second and third order effects; Wave interaction in anisotropic crystals; Frequency conversion; Optical Kerr effect; Optical switching; Four-wave mixing.

Several current topics of interest related to the material in the course will be discussed and presented. In fundamental research, lasers and nonlinear optical techniques can deliver information on the symmetry of materials and interfaces, on the excited states of matter, and on the dynamics of a multitude of material excitations. In technology, nonlinear optical effects are used to change the color of laser beams, to create short laser pulses, and are critical for the understanding and optimization of information-transmission in optical fibers and elsewhere.

What you will learn:

After this course you should be able to understand and operate many different kinds of laser systems, and also to design and build one. Next, you will be able to understand and analyze the nonlinear optical effects that laser beams induce in transparent materials and that are of the second order and of the third order in the optical electric field. If faced with a new phenomenon or effect, you should be able to analyze it with the tools presented in this course and understand its origins and implications.

Required coursework and grading distribution:

30%:	Short Quizzes
30%	Homeworks
40%	Exams

Quizzes are simple, 10-minute questions that you will answer in writing in class, approximately once a week. There will be maybe 7-10 quizzes, graded from 0 (if you are not there or do not write anything) to 4 (if everything is perfect). Only the top 70% will contribute to the grades.

Homeworks are due approximately every two weeks. I will give 1 point for an attempt to solve a problem, 2 points for a correct solution. Solutions to the homeworks will be discussed in class after the problems have been turned in. As a result, I cannot accept late homeworks. Hand in whatever you have done! Homework problems are a very important part of the course. It is the same as athletics, without exercise you cannot be good. Very important: try to solve the homeworks *alone*. It is tempting to do it by committee all together, but this more or less destructs the purpose of the homework, and it is especially unhelpful for the weaker students. Come to me if you have questions.

Exams. There will be a mid-term exam and a comprehensive final exam. The mid-term exam is only counted for the final grade if its grade was better than the grade in the final exam. If both exams are counted, the total grade will be given by $(m + 2f)/3$, where m is the grade of the mid-term, and f the grade of the final.